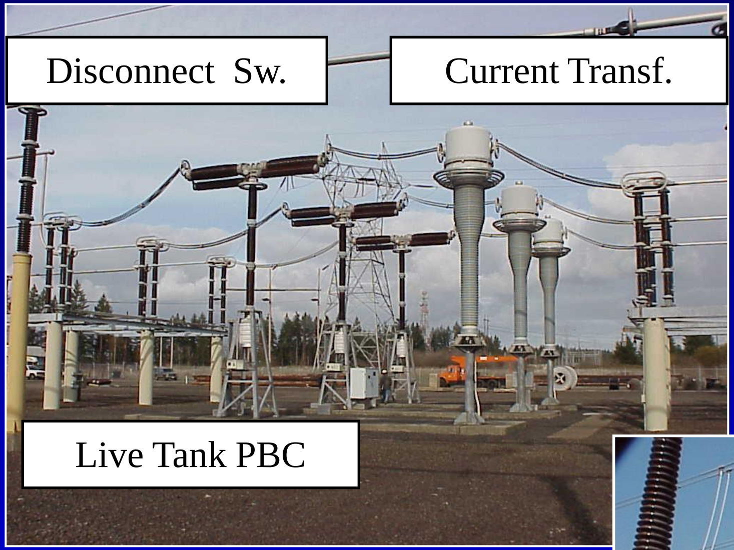
TRANSMISSION SYSTEM

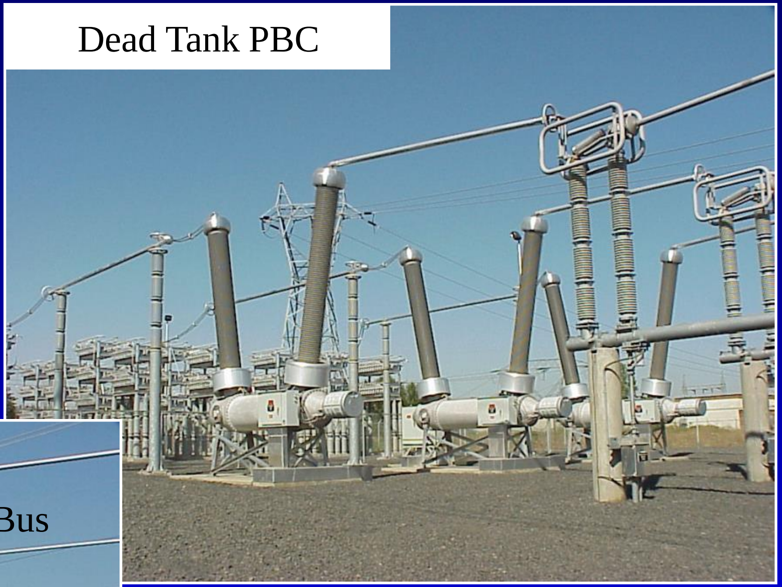
EARTHQUAKE READINESS

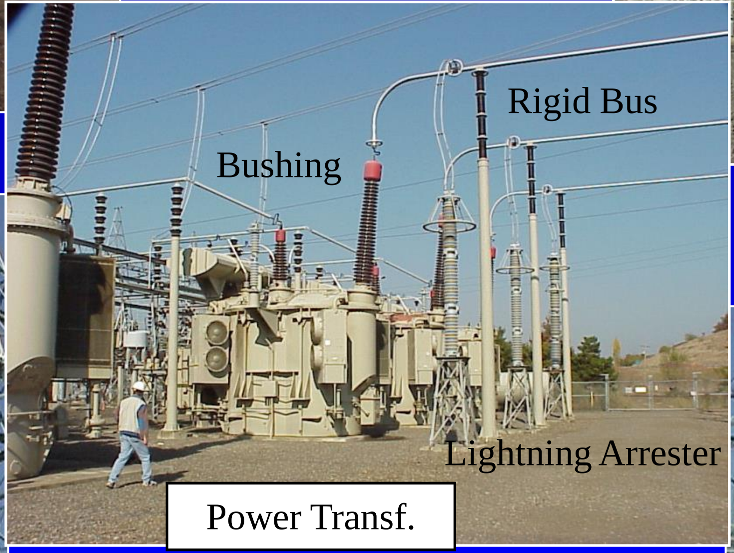


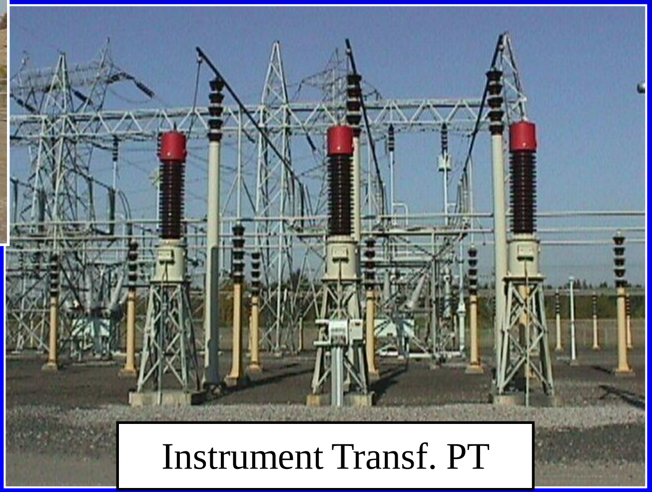


HIGH VOLTAGE SUBSTATIONS

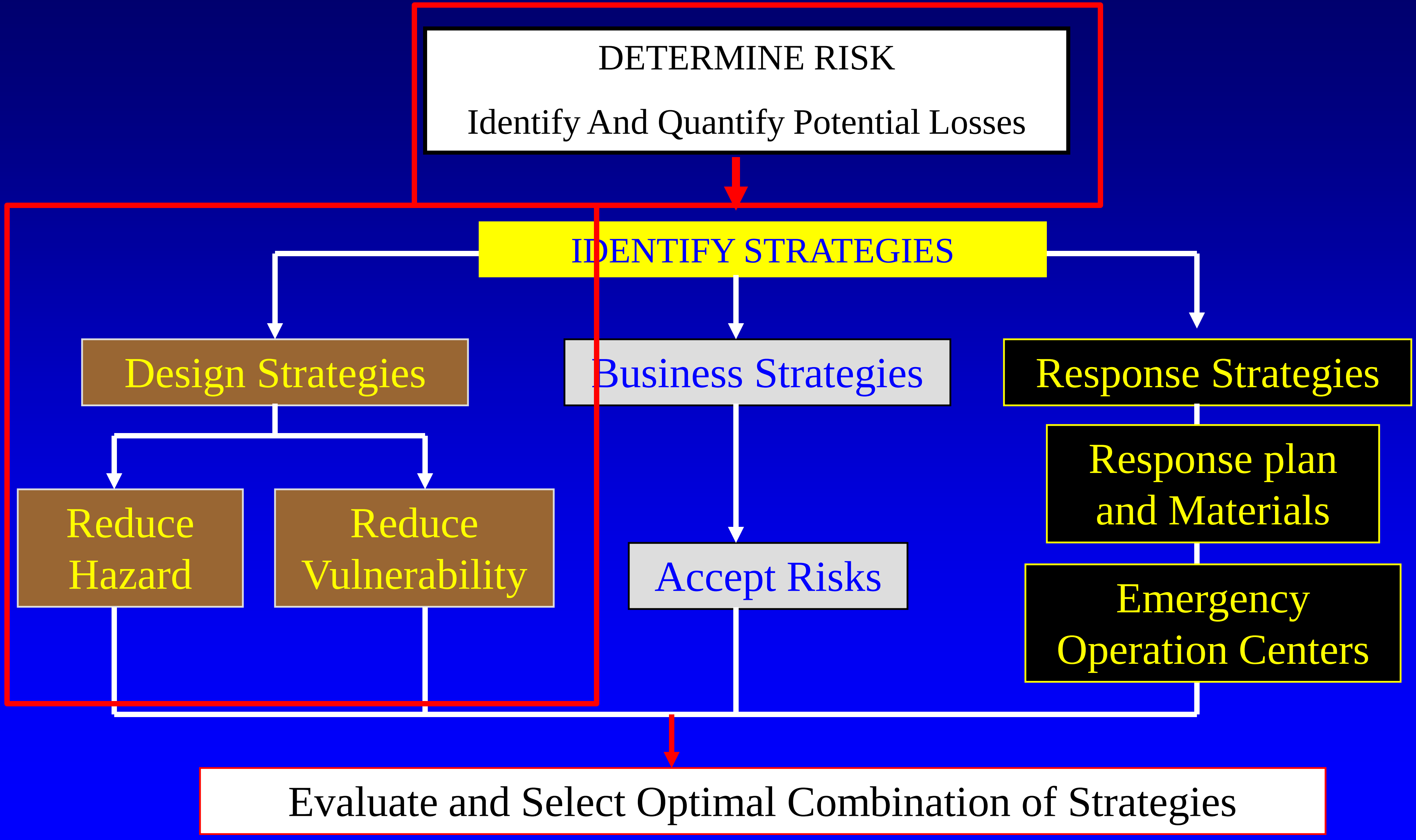


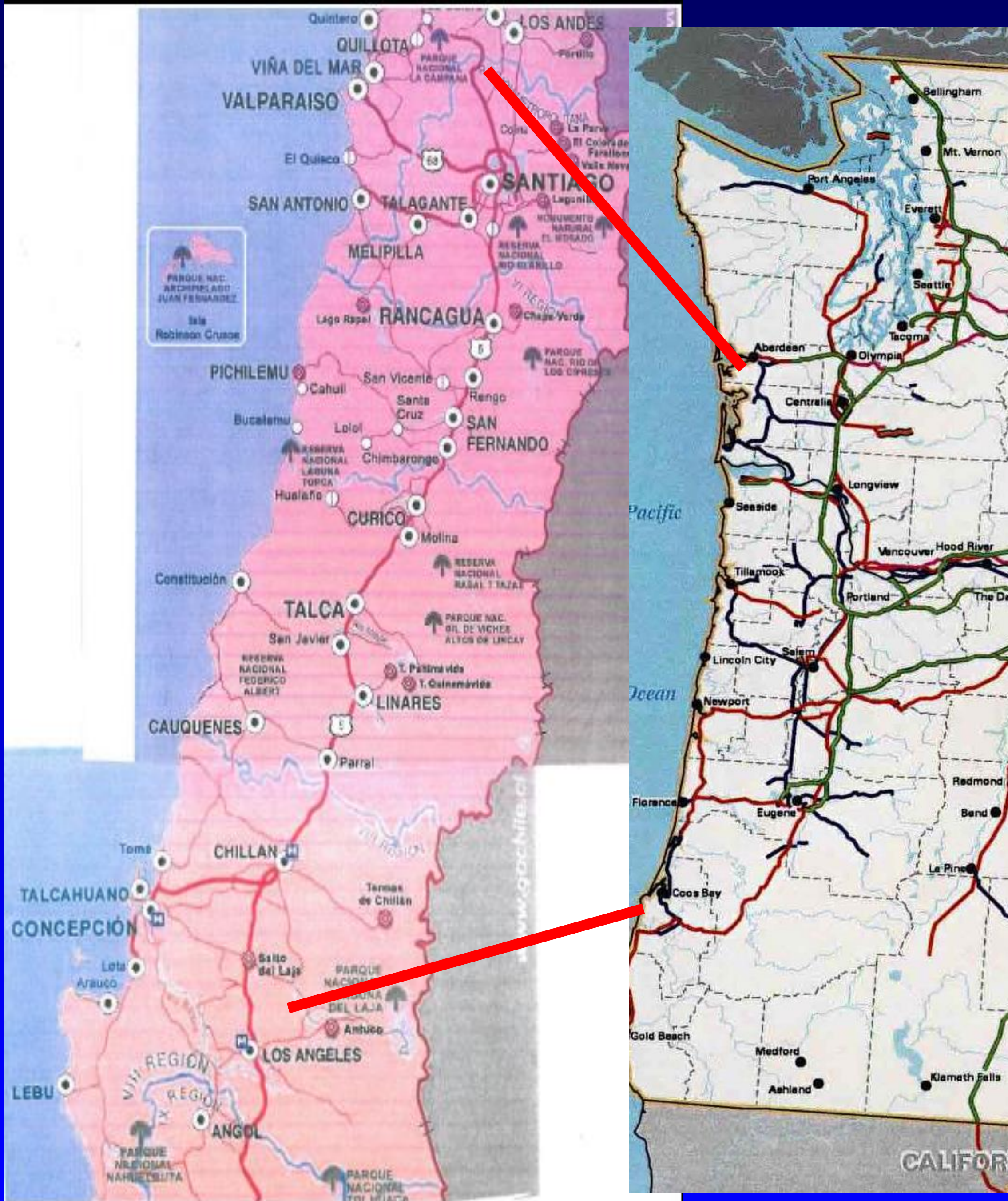






RISK REDUCTION SOLUTIONS

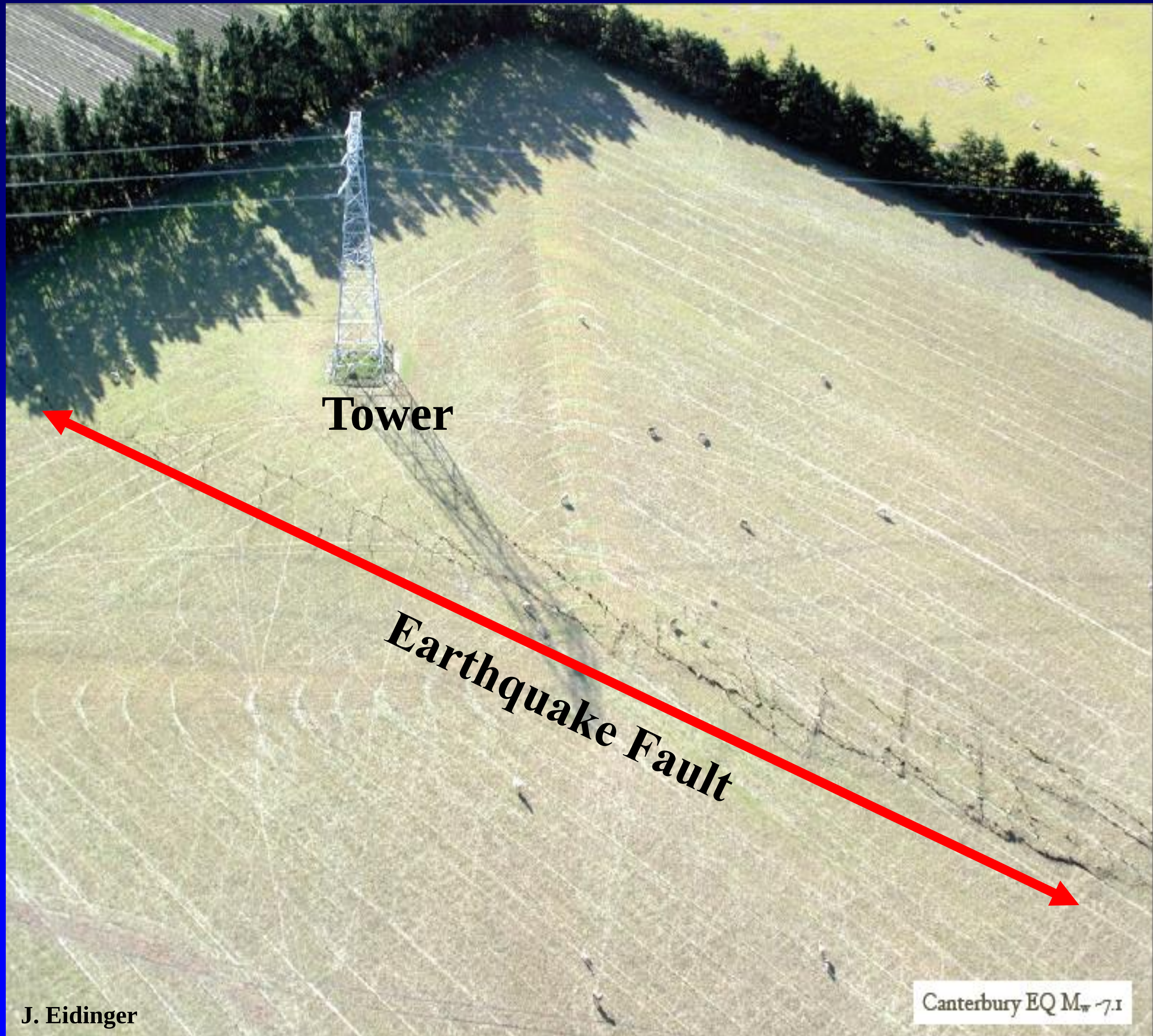




Great Historic Earthquakes in Chile

1575 Valdivia	8.5
1730 Valparaiso	8.7
1751 Concepción	8.5
1835 Concepción	8.5
1868 Arica	9.0
1906 Valparaíso	8.2
1922 Vallenar	8.5
1943 Coquimbo	8.2
1960 Valdivia	9.5
1985 Santiago	8.0
1995 Antofagasta	8.0
2010 Maule	8.8

China 2008, 220 kV Substation

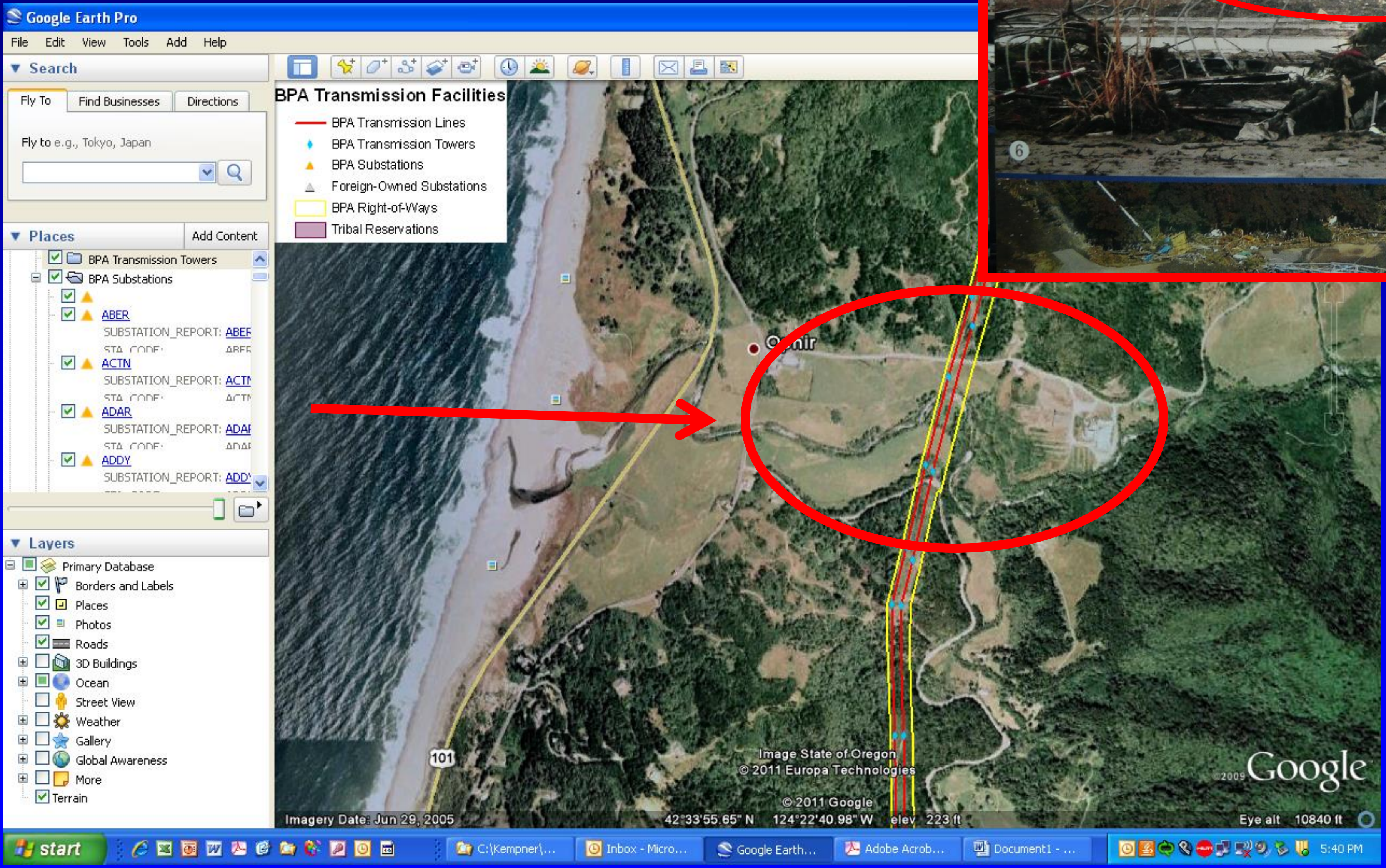

Tower
Earthquake Fault
J. Eidinger
Canterbury EQ M_w ~7.1

Landslides

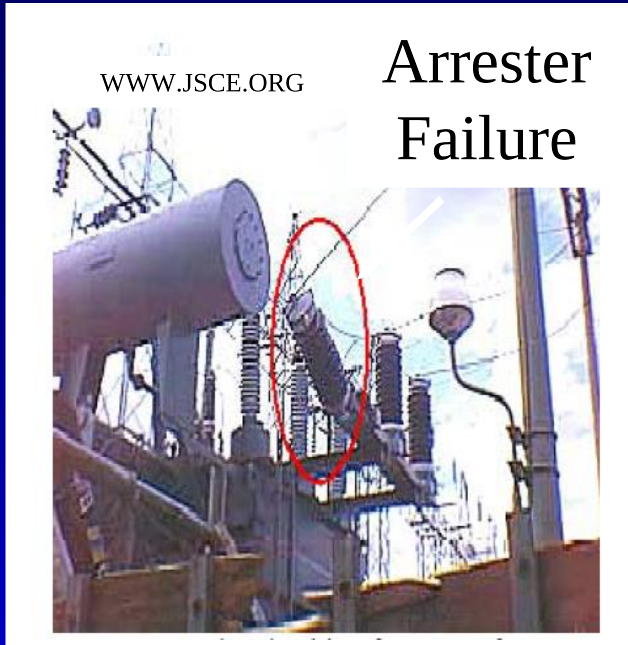
New Zealand, 1968
66 kV

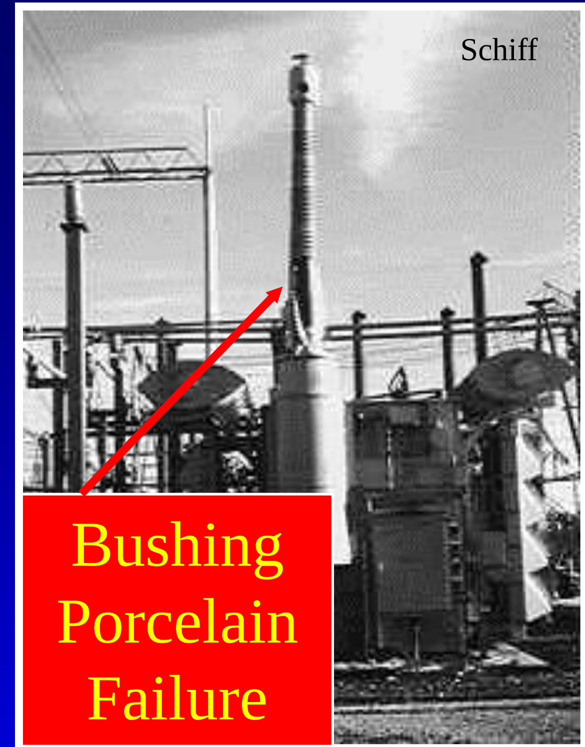
Rock Falls

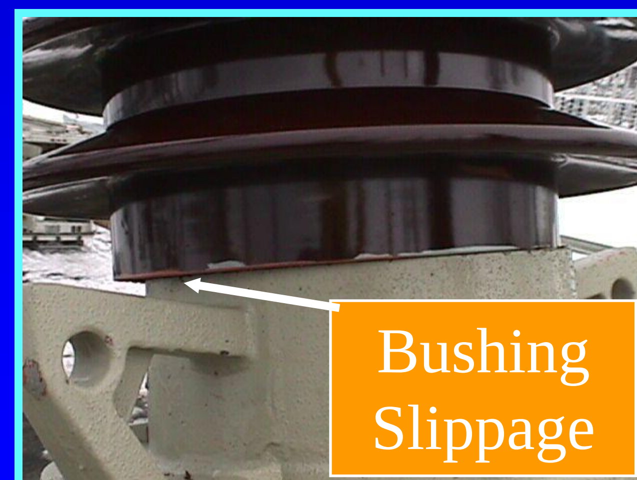
TSUNAMI VULNERABILITY



TRANSFORMER VULNERABILITIES





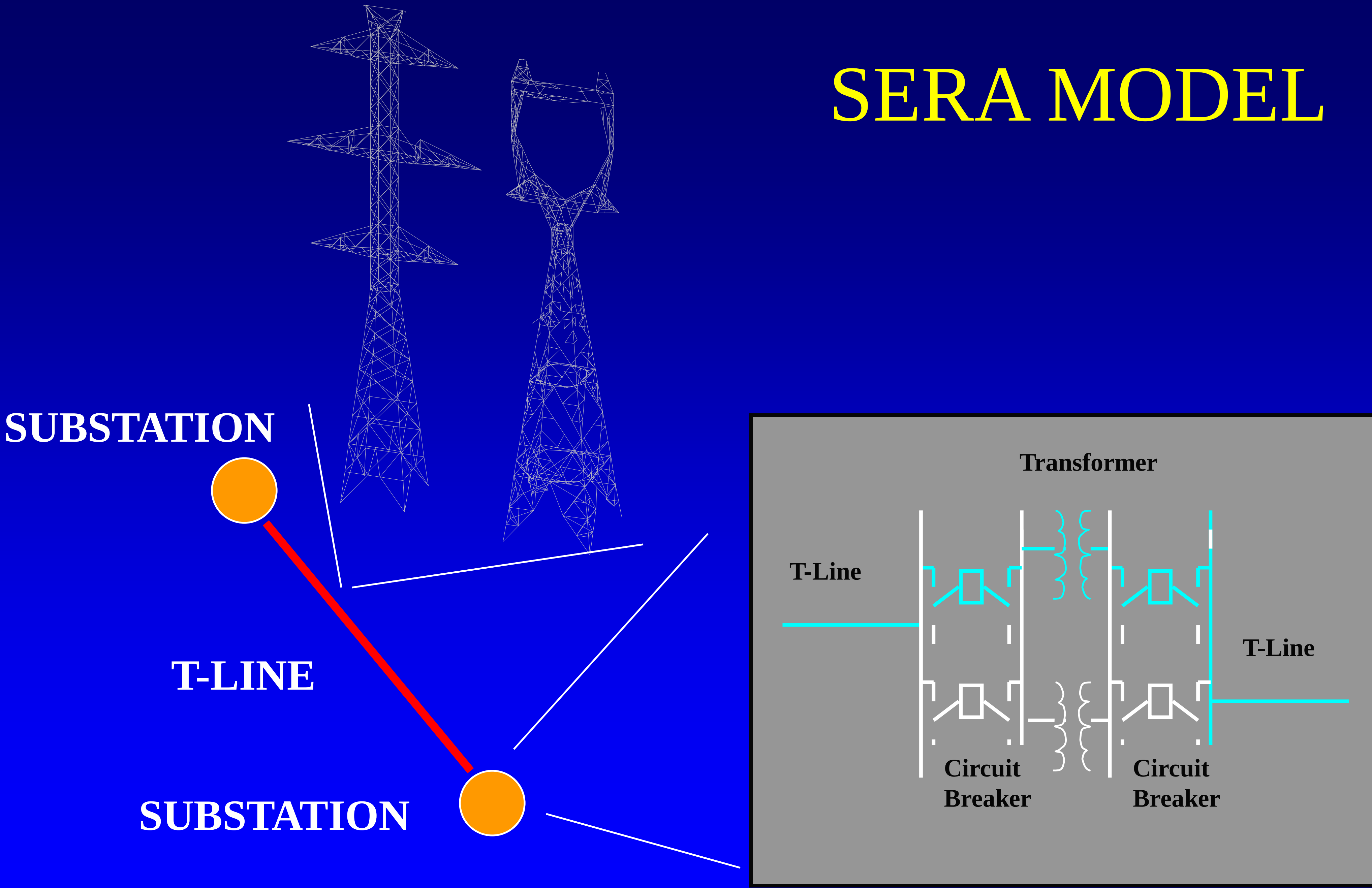


SYSTEM EARTHQUAKE (Extreme Event) RISK ASSESSMENT

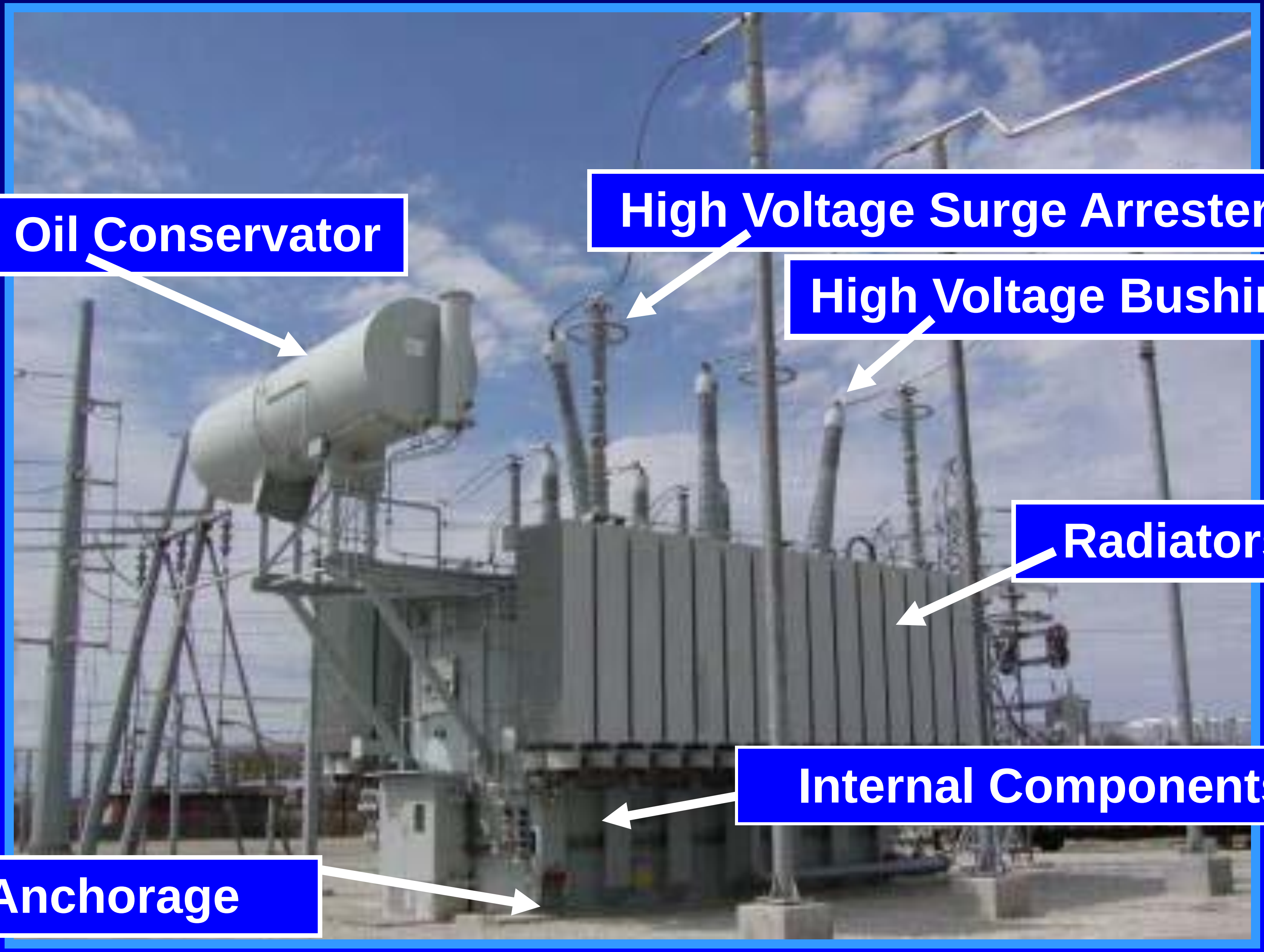
- System Inventory
- Component Fragility
- Scenario Earthquakes
- SERA Results

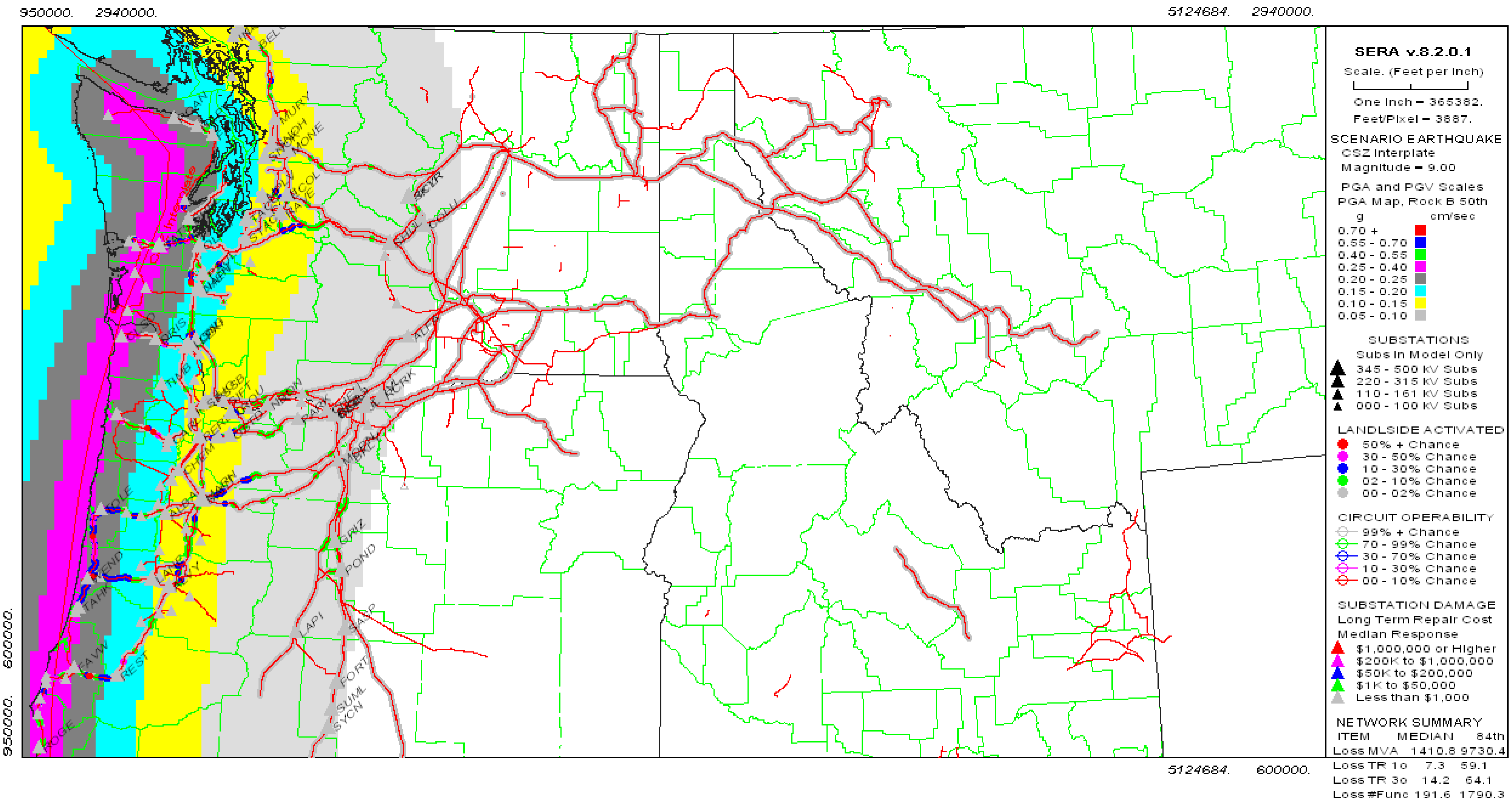
- Originally developed for Southern California Edison (SCE), 1990
- Used to evaluate the San Francisco BART system

SERA MODEL

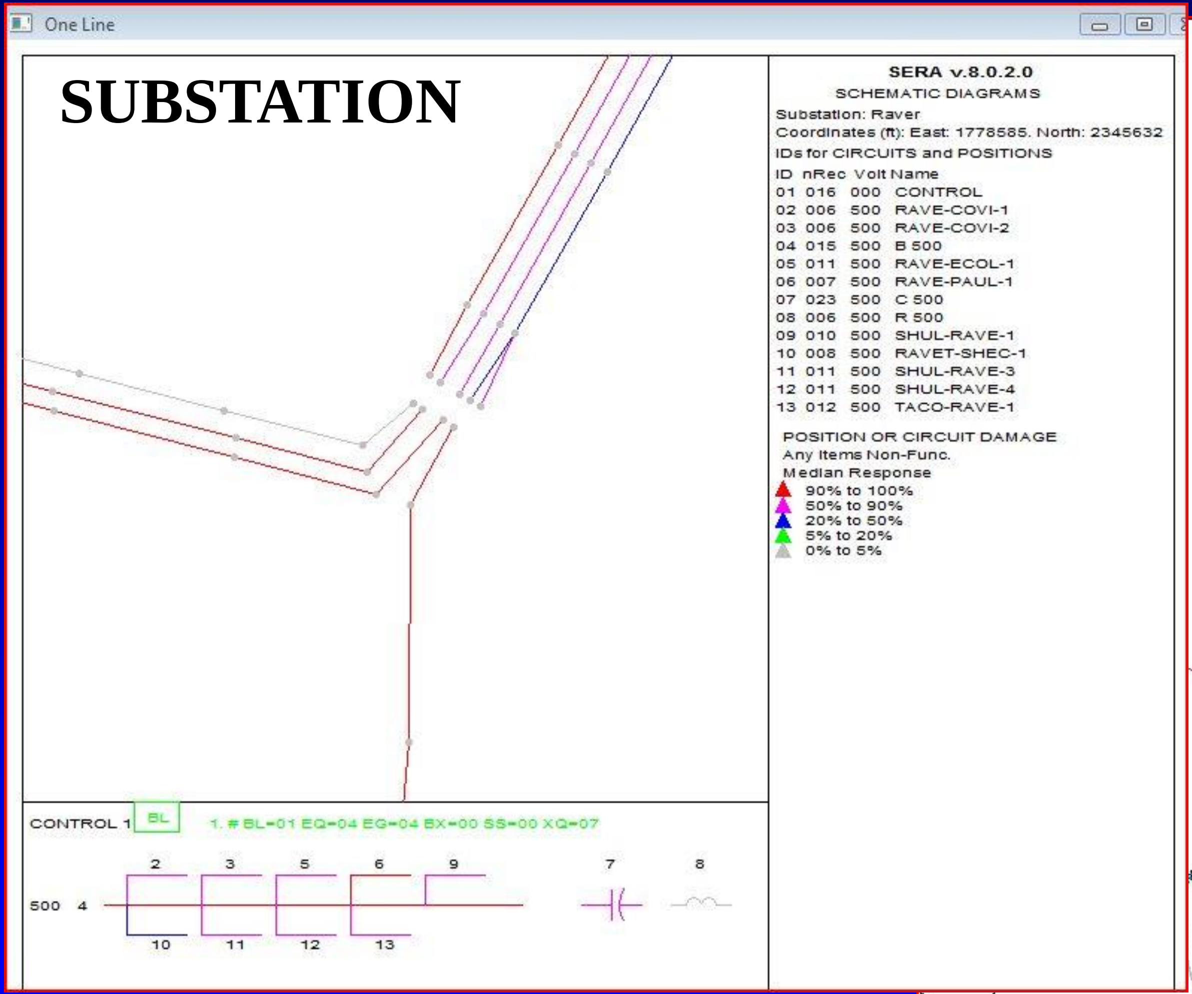

SUBSTATION
T-LINE
SUBSTATION
Transformer
T-Line
T-Line
Circuit
Breaker
Circuit
Breaker

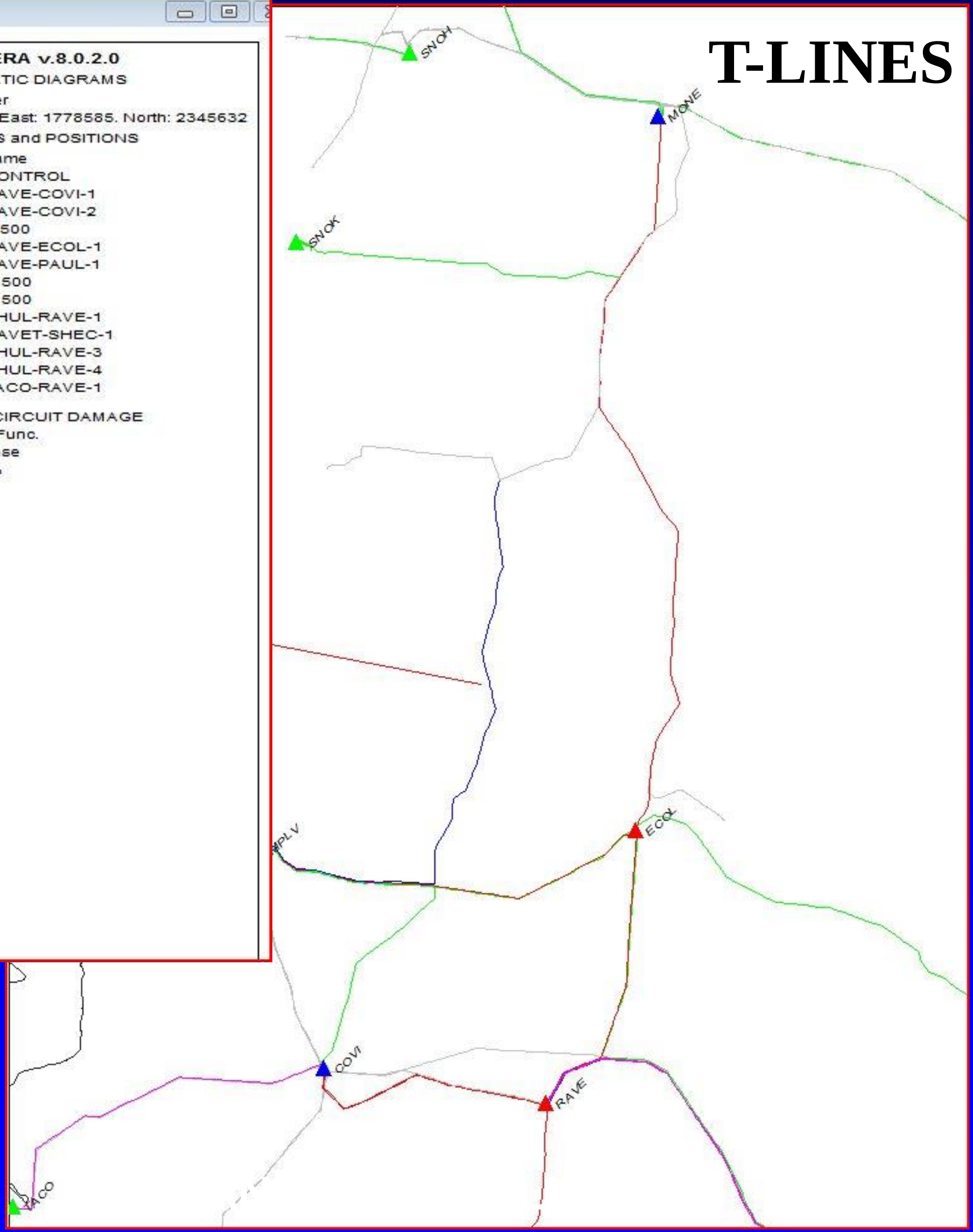
TRANSFORMER VULNERABILITIES





EARTHQUAKE EXERCISE: M9 CASCADIA SUBDUCTION ZONE

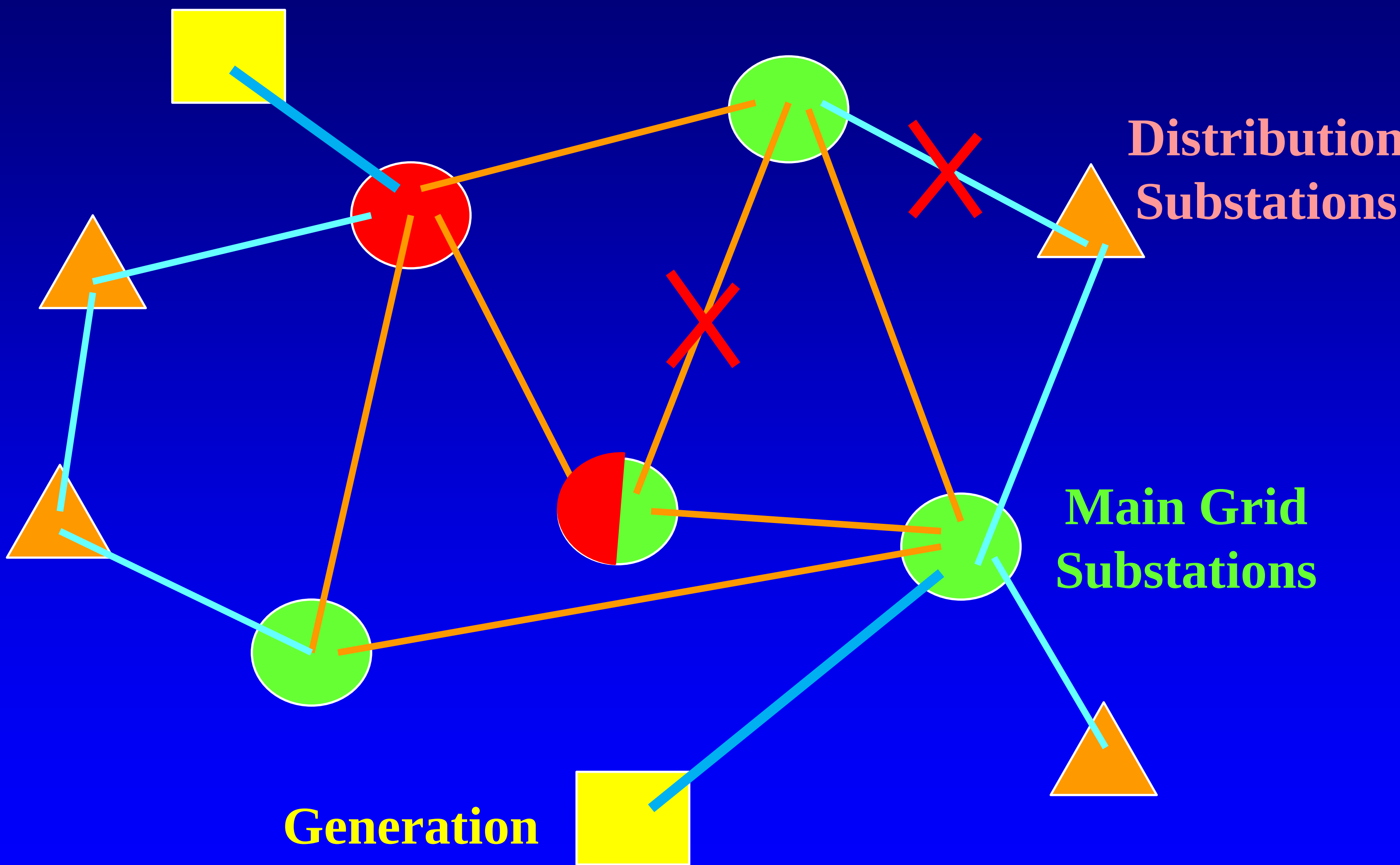




One Line Diagrams

GRAPHICAL DAMAGE DATA

FUNCTIONAL FAILURE

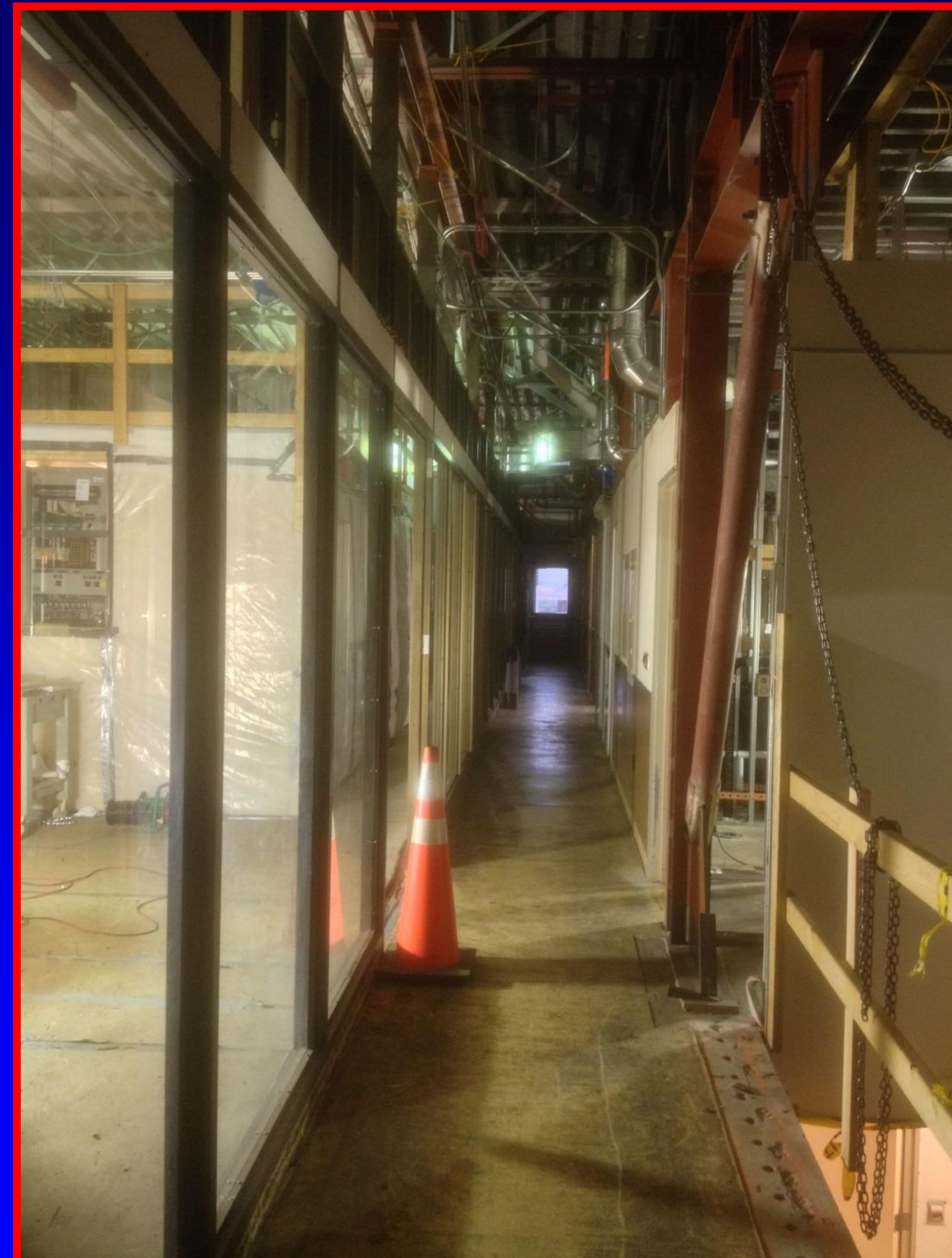


Seismic Mitigation

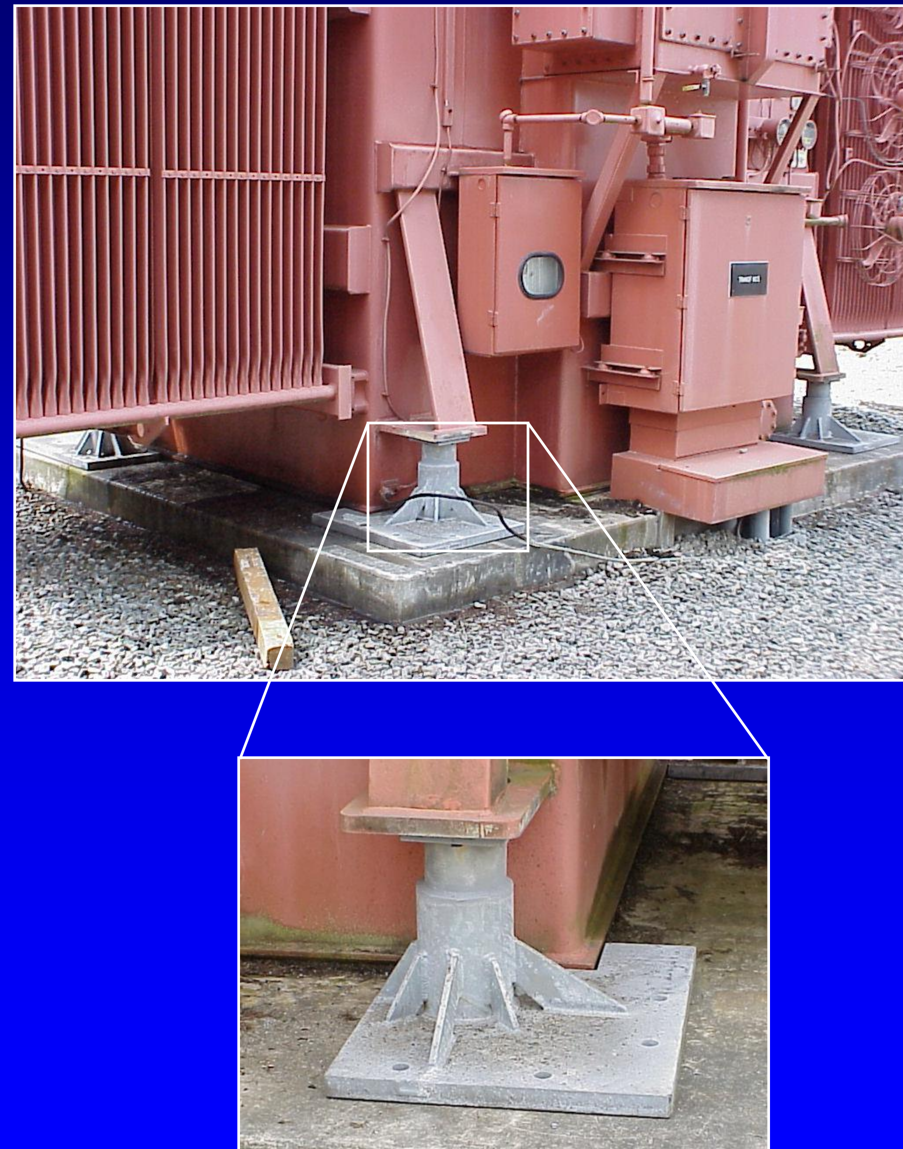
- BUIIDLINGS

Structural and Nonstructural


Genie GS-2646



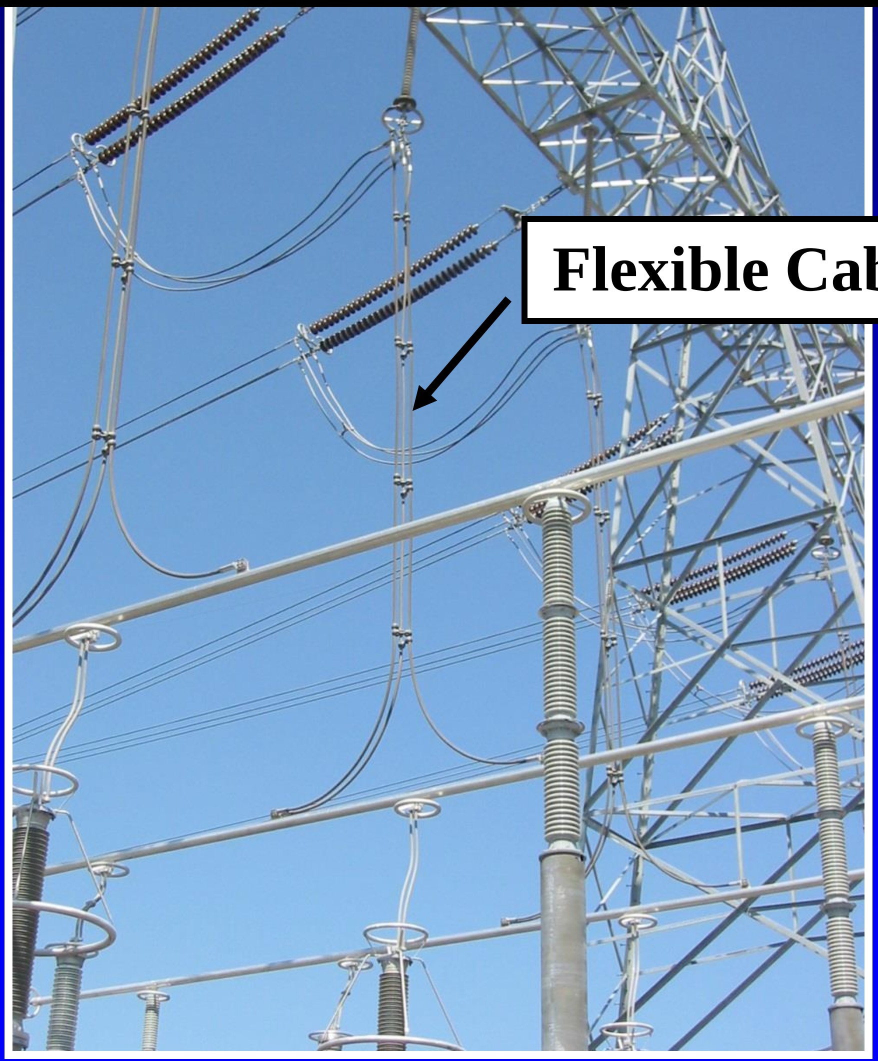
SUBSTATION SEISMIC MITIGATION PROGRAM



SUBSTATION SEISMIC MITIGATION PROGRAM

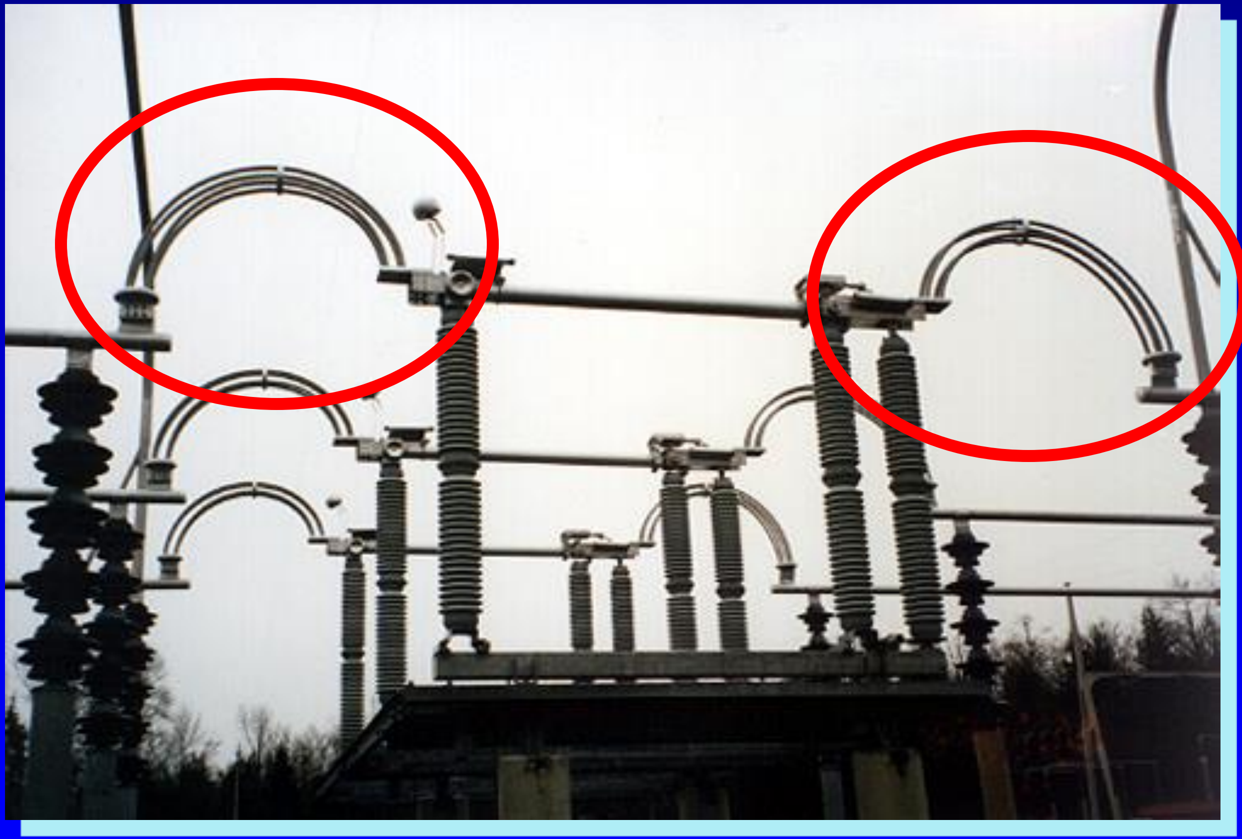
Rigid Bus Riser

Mitigation: Flexible Bus Riser



Disconnect Switch

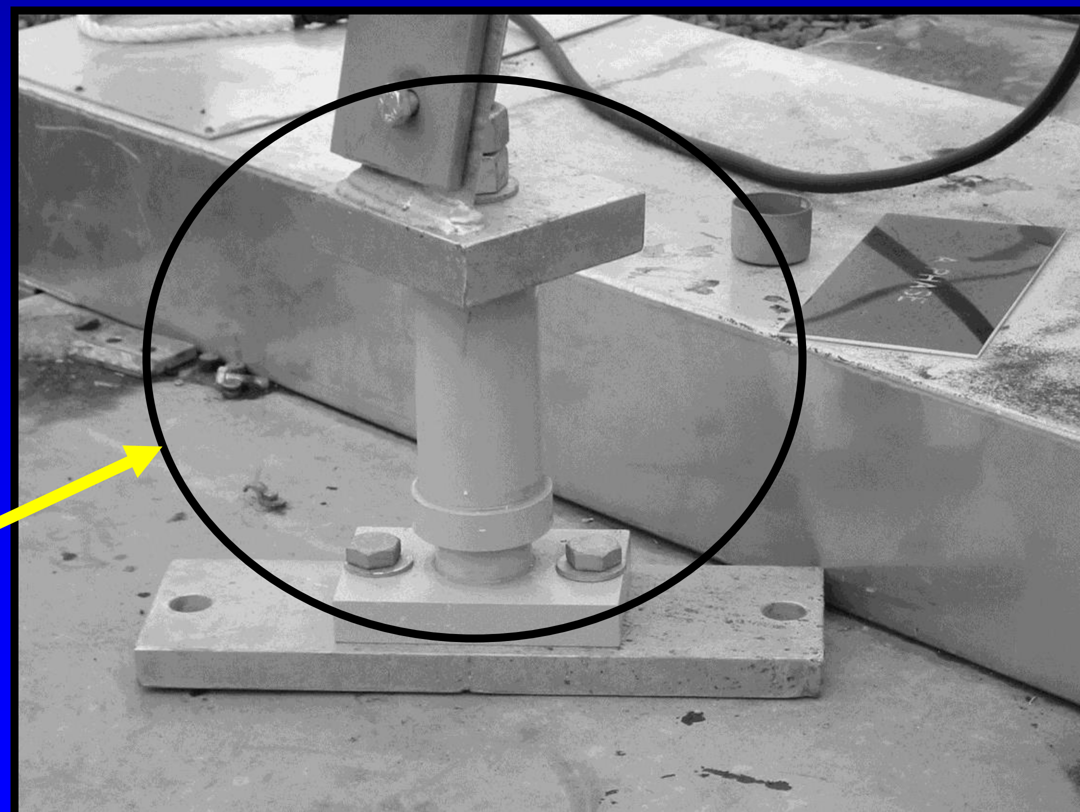
Structural Bracing



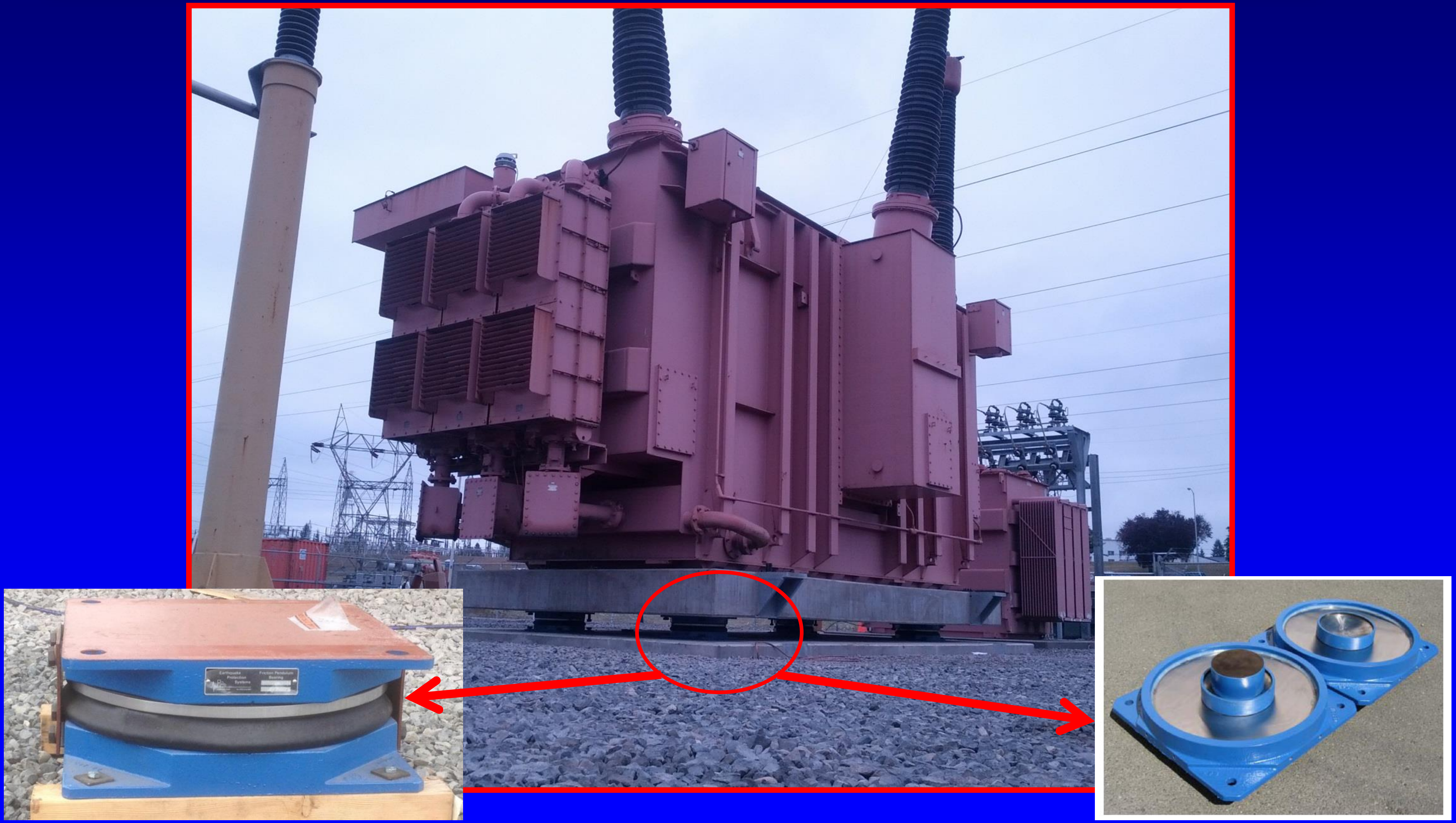
Flexible Connections

SUBSTATION SEISMIC MITIGATION PROGRAM

FIELD RETRO-FIT INSTALLATION OF A RING SPRING FRICTION DAMPER



Seismic Vulnerability of High Voltage Power Transformers (460kV) and Base Isolation Options



TRANSMISSION TOWER SEISMIC MITIGATION PROGRAM

COLUMBIA RIVER

WILLAMETTE RIVER

IEEE

IEEE Recommended Practice for Seismic Design of Substations

693™

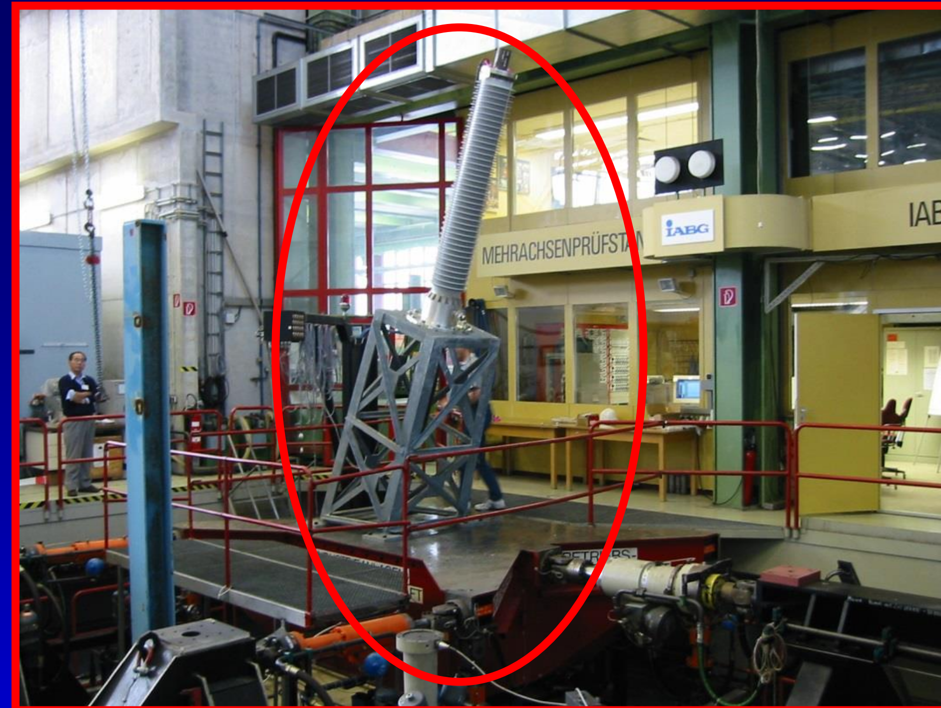
IEEE Power Engineering Society

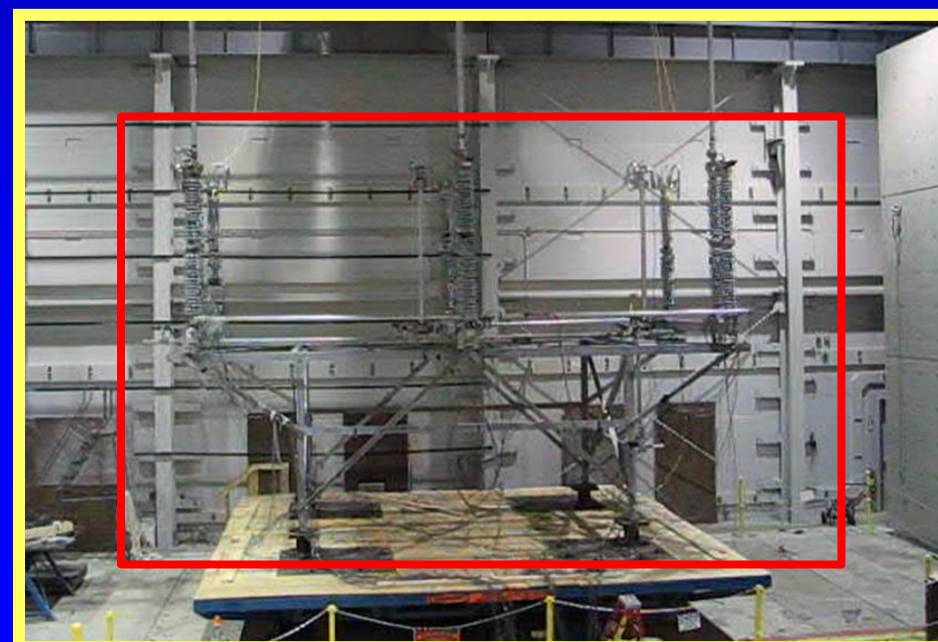
Sponsored by the
Substations Committee

IEEE
3 Park Avenue
New York, NY 10016-5997, USA

8 May 2006

IEEE Std 693™-2005
(Revision of IEEE Std 693-1997)

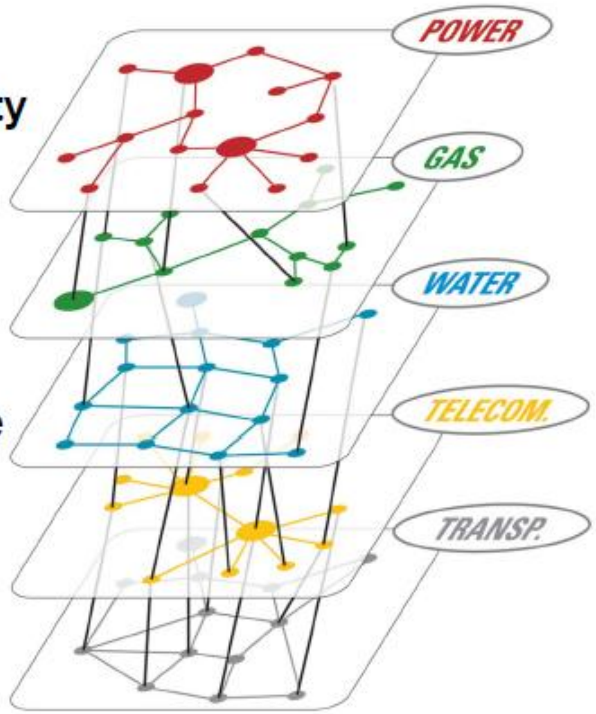




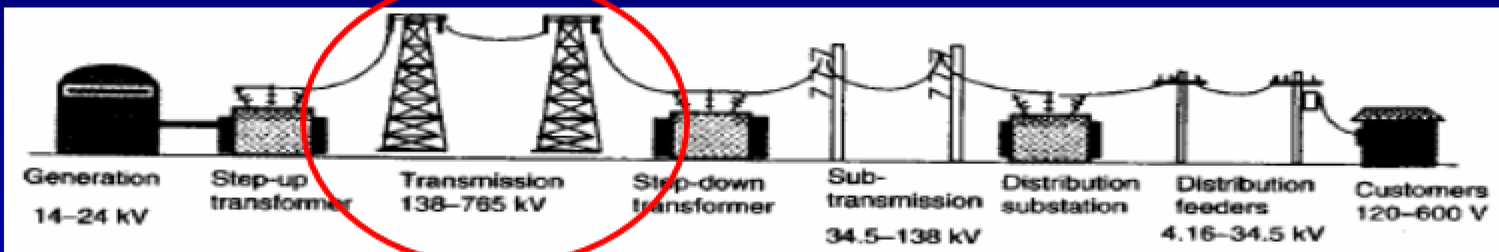
NEW SEISMICALLY DESIGNED SUBSTATION

Infrastructure Systems

- Contemporary complex infrastructure systems
  - Essential for modern society function
  - Large scale and high exposure systems
  - Reached accelerated phase of aging and deterioration
  - More interdependent for optimized operation



Leonardo Dueñas-Osorio



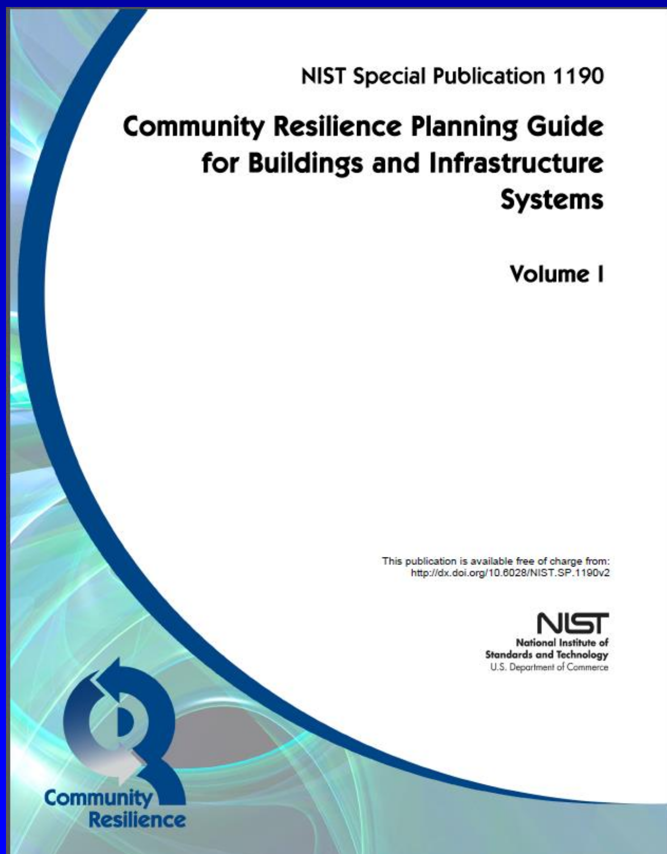
RESILIENCY

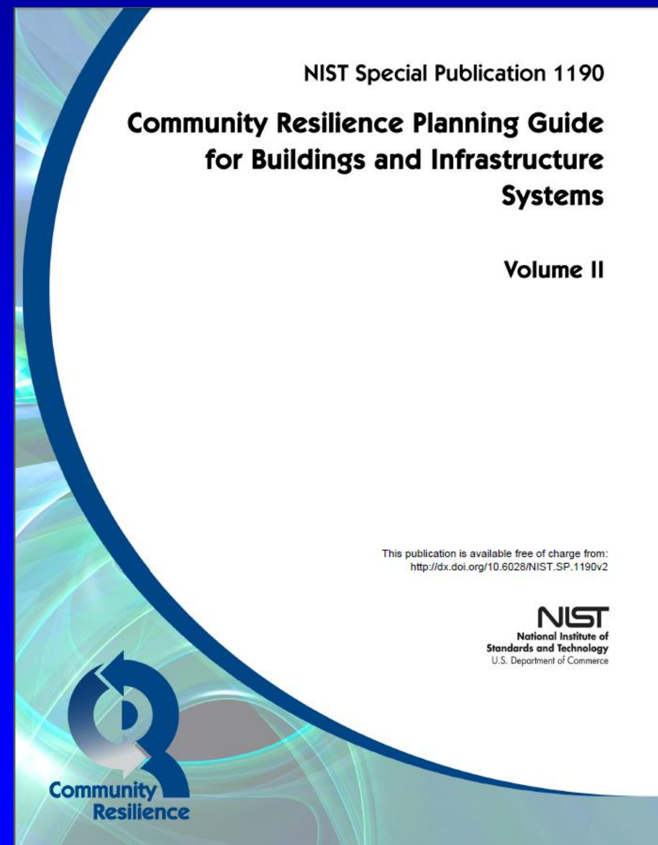
4 R's

- Robustness – Inherent strength
- Redundancy – Alternate options
- Resourcefulness – Mobilize Resources
- Rapidity – Recovery Time

The Oregon Resilience Plan

Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami





Oregon Resilience Plan

KEY TO THE TABLE

Desired time to restore component to 80-90% operational - In 50 Years	**Resilient**	G
Desired time to restore component to 50-60% operational - In 50 Years	**Resilient**	Y
Desired time to restore component to 20-30% operational - In 50 Years	**Resilient**	R
Current state restoration to 90% operational	**Today**	X

TARGET STATES OF RECOVERY

ZONE: COAST (Non Tsunami Zone)

	Event Occurs	0-24 Hours	1 - 3 Days	3-7 Days	1 - 3 Weeks	3 Weeks - 1 Month	1 Month - 3 Months	3Months - 6 Months	6 Months - 1 year	1 year - 3 Years
ELECTRIC										
All - see notes below										
Transmission							X			
Substation								X		
Distribution						X				
NATURAL GAS										
Transmission						X				
Gate Stations						X				
Distribution						X				
LIQUID FUEL										
Transmission										
Storage										

THE CENTER FOR RISK-BASED COMMUNITY RESILIENCE PLANNING

A NIST-FUNDED CENTER OF EXCELLENCE

University Partners:

Colorado State University
Cal Poly Pomona
University of Illinois
University of Oklahoma
Oregon State University
Rice University
Univer. of South Alabama
Texas A&M University
Texas A&M Kingsville
University of Washington

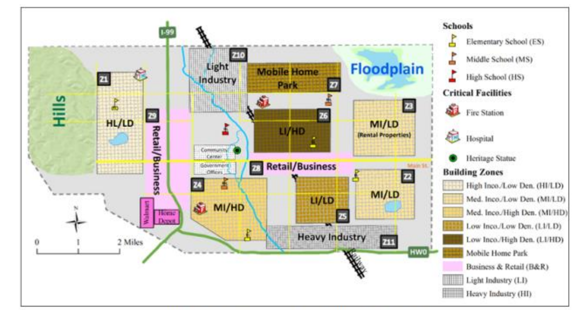


Figure 1. Plan view, showing major features of Centerville

Scope:
Identify the key components and attributes within communities that make then resilient to hazards, develop the NIST Community Resilience Modeling Environment (NIST-CORE) to support risk-informed resilience decisions. (Infrastructure independence, response, and recovery)

The End